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Physico-chemical properties of cocoa *(Theobroma cacao L.)* farm soil in Ikota, Ifedore, Nigeria

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ABSTRACT

The physico- chemical properties of 50 years and 150 years old cocoa farms soils were analyzed for their PH, EA, ECEC,PBS, OM, ON, total nitrogen, phosphorus, OC,OP, particle sizes and mineral analyzes. The PH values of both farms ranged from 5.44±0.06 to 6.41±0.00.The EA were also between 11.12cmol/kg±0.86 to 11.76cmol/kg±1.28. The ECEC of the farms were between 16.91 cmol/kg±0.76 to 18.56 cmol/kg±1.31.The PBS ranged from 39.34%±2.87 to 45.04%±3.49. The TEB of the cocoa farms were between 6.79 cmol/kg±0.33 to 6.80cmol/kg±0.27. The organic carbon of both farms ranged from (31.50g/kg±3.48) to (37.44g/kg±5.15). The organic Phosphorus ranged from (163.59g/kg±7.47) to (185.58g/kg±11.32). The organic matter ranged from (44.65g/kg±1.00) to (54.30g/kg±6.00). The organic Nitrogen also ranged from (1.30g/kg±0.03) to (1.58g/kg±0.17).The total Nitrogen ranged from (0.43%±0.04) to (0.75%±0.06).The clay soil ranged from24.23%±0.39 to 29.05%±0.68, silt ranged from 25.21% ±0.76 to 29.41%±0.88, sand sizes were between 45.74% ±0.52 to 46.35%±0.74, while the particle densities of the two farms were between 2.18g/cm^3 ±0.07 to 2.56g/cm^3±0.06. The mineral analyses showed that the mineral contents ranged from 0.045mg/kg±0.05 to 0.52mg/kg±0.03. The soil samples showed traces of heavy metals like Pb, mn, Ni, Cd.

Key words: Ikota, PH, EA,PBS, ECEC,Cd, Mn TEB, Particle sizes.

INTRODUCTION

Ikota, is a town located in Ifedore local Government area, in Ondo state, Nigeria, its geographical coordinates are 7° 21' 0" North, 5° 9' 0" East. Their major activities in the town include farming(well Known for cocoa growing), fishing and rearing of animals. Agriculture plays an important and strategic role in the revival of Nigerian national economy and cocoa (Theobroma cacao L.) remains a major export crop in Nigeria. In 1998, a revenue of 7459.3

million Naira (US$ 53,280 at 140 per US$) was derived from dried cocoa beans (half of the income attributed to the total export of major agricultural products)[1]. Cocoa was first cultivated in the western region of Nigeriain 1890[2]. Its cultivation gained prominence rapidly in Nigeria such that by 1965, Nigeria became the second largest producer in the world[2] (Adegeye, 1996).In general, cocoa producing states lie within the rainforest zone of Nigeria which includeOndo, Ogun, Oyo,Ekiti, Ogun, Edo, Delta, Cross-Rivers and Akwa-Ibom. However, over 50% of the total quantity of cocoa produced for export or utilized locally per annum comes from Ondo State[2]. The production, however, has declined in recent years; a fact attributed partly to poor soil quality[3-4] In Nigeria, and elsewhere in the tropics, extensive studies have been carried out on many tree crops including cocoa[5-7]. Previous records on soil survey between 1951 and 1962, within the cocoa belts of Nigeria revealed that about 62% of Nigeria cocoa is grown on good or fairly good soils and the remaining thirty eight per cent on poor or very poor soil [8]. It has also been shown in Modern Applied Science www.ccsenet.org/mas36experimentally by the Cocoa Research Institute of Nigeria (CRIN) that continuous cultivation of cocoa at same farmland leads to appreciable decline in physical and chemical properties of the soil[9-10].Crop production involves a complex interaction between the environment, soil parameters, and nutrient dynamics. Because of this fact, the soil must be studied in terms of the productive potentials. Failure to understand these complexities has resulted in lack of good crop production and management techniques; hence agricultural production has tended to be low. Soil fertility decline is considered as an important cause for low productivity of many soils[11]. It has not received the same amount of research attention as soil erosion; probably because as soil fertility declines less visible and less spectacular, and more difficult to assess. Assessing soil fertility decline is difficult because
Most soil chemical properties either change very slowly or have large seasonal fluctuations. This decline includes; nutrient depletion, nutrient mining, acidification (decline in pH and or an increase in exchangeable Al), loss of organic matter and increase in toxic elements (e.g., Al, Mn)[12].

In the present study, physico-chemical properties of 50 years and 150 years old cocoa farm soils namely pH, organic matter, Total nitrogen, exchangeable acidity, effective cation exchange capacity, phosphorus, moisture content, total exchangeable bases, mineral elements, organic carbon and organic phosphorus will be examined.

EXPERIMENTAL SECTION

Study Area

50 years and 150 years cocoa farms were selected in Ikota, these old cocoa farms were chosen because they are the predominant cocoa farms in the area and the town being one of the largest area that produces cocoa in Ondo state.

Sampling

Sampling design was based on two principles: first, the need to spread sample sites objectively over the study area and second, the need to ensure that plant and site characteristics are adequately depicted. The entire plantation at each farm was divided into three plots from each of which samples were collected. Soil samples were collected from two sampling depths 0–10cm and 10–20cm, thereafter referred to as topsoil and subsoil . The sampling was restricted to this

zone because the zone provides the bulk of plant nutrients [13]. Samples were collected inside labeled polythene bags. Random sampling technique was adopted.

Sample Treatment and Analysis

Soil samples were air-dried, sieved, mixed together and analyzed in the laboratory using standard techniques. Particle size composition was obtained by hydrometer method [14]. Soil pH was determined in water [15], Organic carbon content was found by the modified $K_2Cr_2O_7$ digestion of Walkley-Black method[16]. The cation exchange capacity (CEC) was determined by adding the 1 M KCl extractable acidity to cations (Ca^{2+}, $Mg^{2+,}$ Na^{+}, K^{+}) exchanged by neutral 1 M $NH_4C_2H_3O_2$ (pH 7) as described in Thomas[17]. The K^{+} and Na^{+} were measured with flame photometer while the Mg^{2+} and Ca^{2+} were determined with atomic absorption spectrophotometer. The exchangeable acidity was determined by titration and the effective cation exchange capacity (ECEC) was obtained by summation of exchangeable cations, exchange acidity. The percentage base saturation was done by calculation. The mineral analysis was done by soaking the soil in dilute water and Atomic absorption spectroscopy machine was used, total nitrogen was determined using digestion methods.[16].

RESULTS AND DISCUSSION

The physico- chemical properties of the two different cocoa farm soils were analyzed. The PH values of 50 years old cocoa farm (6.41±0.00) was higher than that of 150 years old cocoa farm(5.44±0.06). The effect of soil pH is profound on the solubility of minerals and nutrients and It is regarded as a useful indicator of other soil parameters [18]. Particularly, it provides useful information about the availabilities of exchangeable cations (e.g Ca^{2+}, Mg^{2+}, K^{+}, e.t.c) in soils. The PH values of both farms showed that the soil contains more exchangeable cations. The exchangeable acidity of 50 years old cocoa farm(10.12cmol/kg±0.86) was lower than that of 150 years old cocoa farm(11.76cmol/kg±1.28).The effective cation exchange capacity(ECEC) of 50 years old cocoa farm(16.91cmol/kg±0.76) was lower than that of 150 years old cocoa farm(18.56cmol/kg±1.31).The ECEC is a summation of total exchangeable bases and exchangeable acidity. It is highly needed for the estimation of contaminant transport potential and sorption capacity for any soil location i.e. the total number of cations it can retain on its adsorbent complex at a given pH..The presence of these high values of ECEC indicates the presence of less clay and high organic matter. The percentage base saturation of 50 years old cocoa farm (45.04%±3.49) was higher than that of 150 years old cocoa farm(39.34%±2.87).The total exchangeable bases of 50 years old cocoa and 150 years old cocoa farm were the same(6.80cmol/kg±0.33). These percentages are valuable indicators of the chemical richness of these locations, and will assist to determine the biological activity, the quality of its structure and reserves of nutrient element The organic matter of 50 years old cocoa farm (44.65g/kg±1.00) was lower than that of 150 years old cocoa farm(54.30g/kg±6.00). The level of organic matters in soils influences a number of soil chemical and physical properties. The high organic matter content of 150years old and 50 years old cocoa farm in Ikota were responsible for the high yield of cocoa, because of high decayed plants and animals. The organic Nitrogen of 50 years old cocoa farm(1.30g/kg±0.03) was lower than that of 150 years old cocoa farm(1.58g/kg±0.17).The total Nitrogen of 50 years old cocoa farm(0.75%±0.06) was higher than that of 150 years old cocoa farm(0.43%±0.04), the total Nitrogen recorded in the two farms were greater than 0.2% minimum requirement of nitrogen needed for plant growth and

higher than the world average nitrogen content(<0.15%)[19] .The organic carbon of 50 years old cocoa farm(37.44g/kg±5.15) was higher than that of 150 years old cocoa farm(31.50g/kg±3.48). The organic Phosphorus of 50 years old cocoa farm (163.59g/kg±7.47) was lower than that of 150 years old cocoa farm(185.58g/kg±11.32). The clay soil of 50 years old cocoa farm(29.05%±0.68) was higher than that of 150 years old cocoa farm(24.23%±0.39). The silt of 50 years old cocoa farm (25.21%±0.76) was lower than that of 150 years old cocoa farm(29.42%±0.88). The sand of 50 years old cocoa farm (45.74%±0.52) was lower than that of 150 years old cocoa farm(46.35%±0.74).However the soil contain significant percentage of sand, in both farms. Soils composed small proportion of silt and clay don't compress (collapse) as they lose water. Such soils continue to have high permeability to oxygen during sub aerial exposure. Soils of intermediate grain size composition exhibit partial compression. Indeed, compressibility has been found to be linearly correlated to silt-clay content[19]. This compressibility as experienced may be responsible for the high quality of cocoa in Ikota farm. The mineral element of of 50 years old cocoa farm were: Cu(0.05mg/kg±0.00), Fe(0.34mg/kg±0.01), Zn(0.41mg/kg±0.02),Pb(0.01mg/kg±0.00),Ni(0.02mg/kg±0.00), Cd(0.05mg/kg±0.00) and Mn(0.53mg/kg±0.02). The mineral element of of150 years old cocoa farm were: Cu(0.03mg/kg±0.02), Fe(0.33mg/kg±0.02), Zn(0.46mg/kg±0.03),Pb(0.01mg/kg±0.00),Ni(0.03mg/kg±0.00), Cd (0.04mg/kg±0.00) and Mn(0.58mg/kg±0.01).The presence of trace quantity of heavy metals like cadmium and zinc is an indication that the soil may be toxic for planting food crops. [20] and the nearby streams of water may contain high level of contaminants [21].

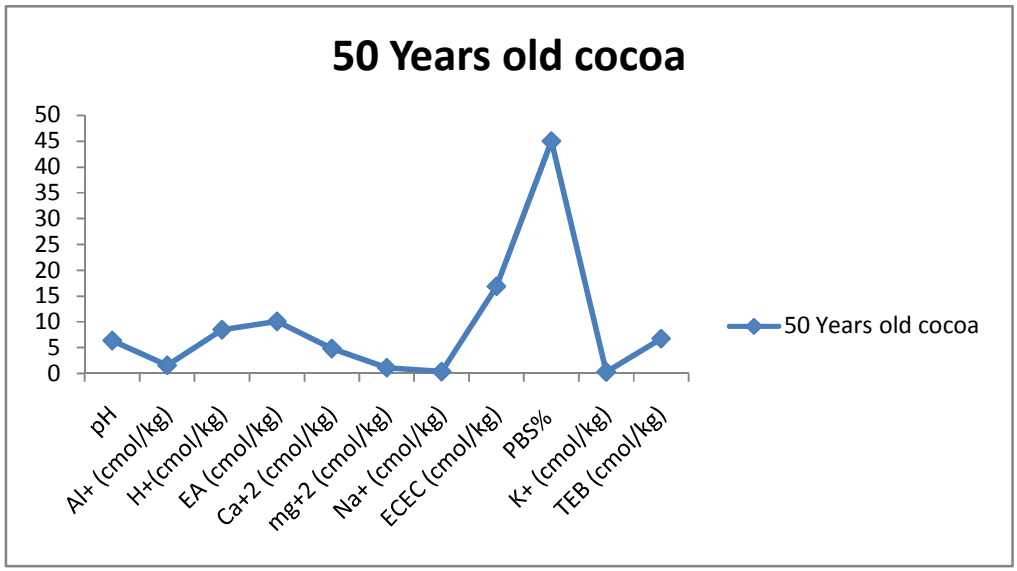

Fig. 1: A graph showing the pH, Ca^{+} and ECEC of 50 years old cocoa farm soil

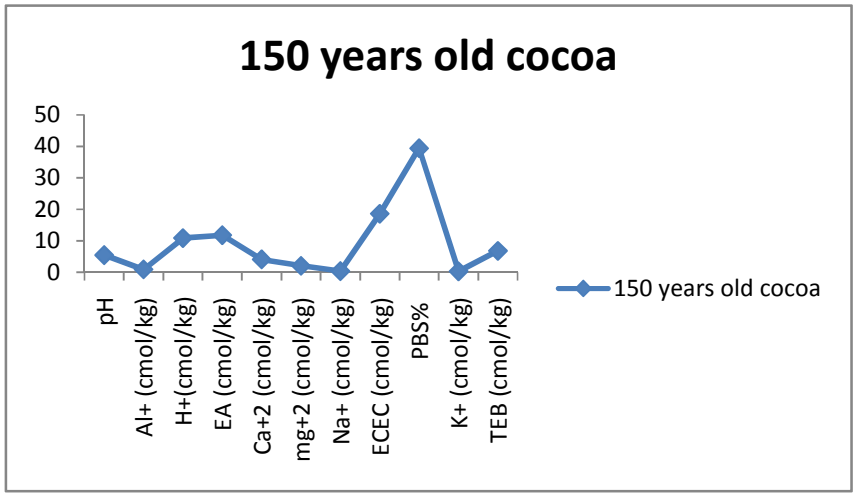

Fig. 2: A graph showing the pH, Ca^{+} and ECEC of 150 years old cocoa farm soil

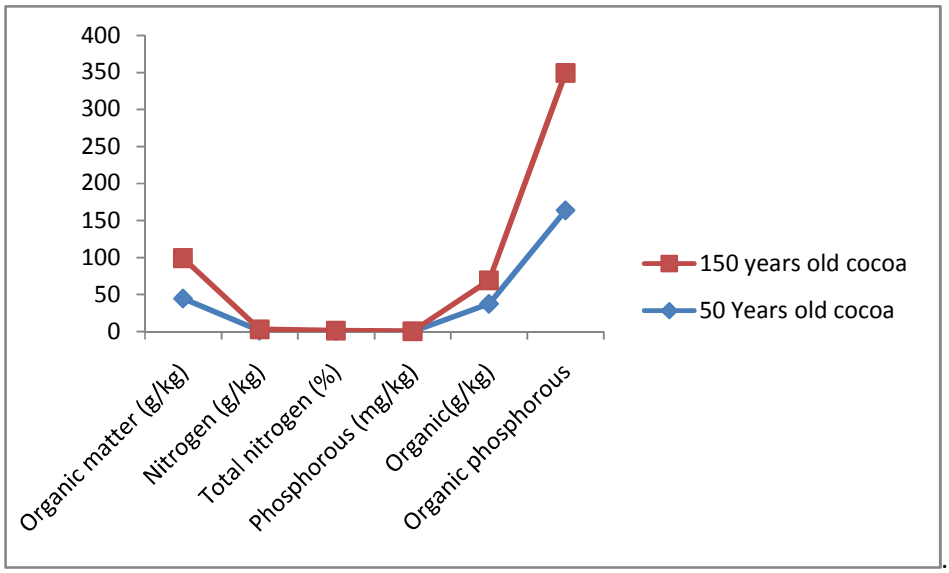

Fig. 3: A graph showing the mean of chemical properties of 50years and 150 years old cocoa farm soil

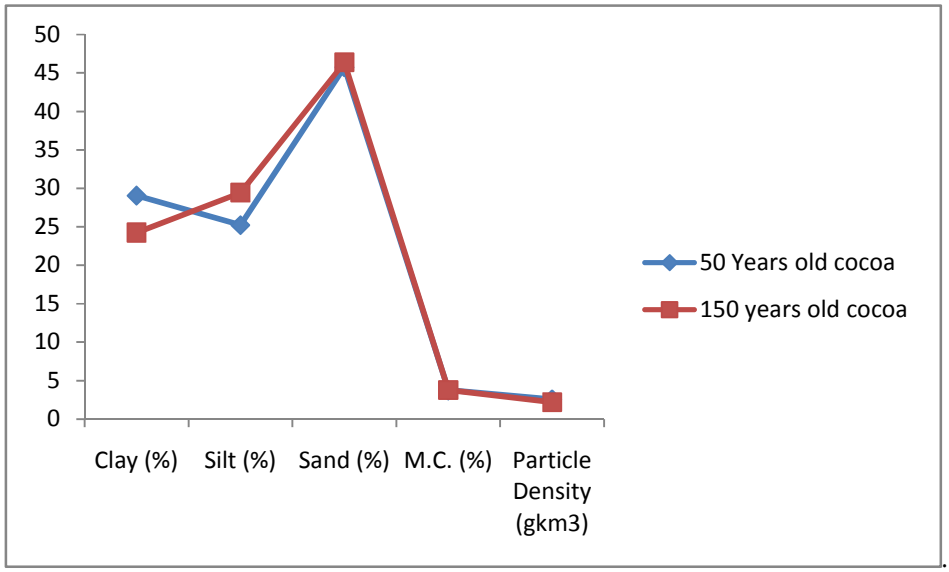

Fig.4: A graph showing the mean of physical properties of 50years and 150 years old cocoa farm soil

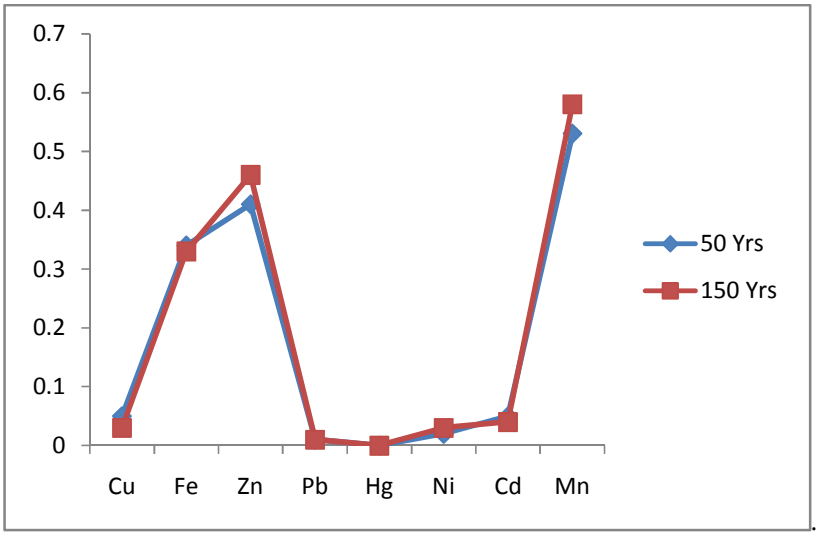

Fig.5: A graph showing the mean of mineral analysis of 50years and 150 years old cocoa farm soil

Table 1: 95% Confidence interval for mean

Parameter	Farm	Lower bound	Upper bound	Minimum	Maximum
pH 50	50 yrs	6.40	6.41	6.40	6.41
150	150 yrs	5.37	5.51	5.36	5.50
Al^{+}(cmol/kg)	50 yrs	0.90	2.30	0.80	2.30
	150 yrs	0.25	1.59	0.50	1.60
H^{+} (cmol/kg)	50 yrs	5.65	11.39	6.10	12.30
	150 yrs	7.04	14.64	8.00	15.80
EA (cmol/kg)	50 yrs	7.73	12.51	7.70	13.10
	150 yrs	8.19	15.33	8.50	16.30
Ca^{2+}(cmol/kg)	50 yrs	3.89	5.83	3.70	5.90
	150 yrs	3.68	4.52	3.80	4.60
Mg^{2+}(cmol/kg)	50 yrs	0.25	2.07	0.10	1.90
	150 yrs	1.27	2.81	1.30	2.80
Na^{+}(cmol/kg)	50 yrs	0.32	0.51	0.34	0.50
	150 yrs	0.33	0.40	0.33	0.39
ECEC	50 yrs	14.79	19.02	14.38	18.97
	150 yrs	14.92	22.19	14.58	22.78
PBS	50 yrs	35.37	54.72	32.31	52.27
	150 yrs	31.36	47.31	29.08	44.94
K^{+} (cmol/kg)	50 yrs	0.33	0.38	0.33	0.38
	150 yrs	0.15	0.44	0.22	0.50

Table 2: 95% confidence for mean of chemical properties

Parameter	Farm	95% confidence for mean of chemical properties		Minimum	Maximum
		Lower bound	Upper bound		
Organic matter (g/kg)	50 yrs	41.86	47.44	31.20	47.24
	150 yrs	37.64	70.96	31.48	64.39
Organic Nitrogen (g/kg)	50 yrs	1.22	1.37	1.20	1.37
	150 yrs	1.09	2.06	0.91	1.87
Total Nitrogen (%)	50 yrs	0.58	0.92	0.56	0.88
	150 yrs	0.31	0.54	0.32	0.56
Phosphorous (mg/kg)	50 yrs	0.04	0.40	0.09	0.50
	150 yrs	0.03	0.18	0.05	0.19
Organic carbon (g/kg)	50 yrs	23.14	51.75	23.86	47.24
	150 yrs	21.83	41.16	18.26	37.35
Organic Phosphorous (mg/kg)	50 yrs	142.86	184.32	136.20	178.80
	150 yrs	154.13	217.03	141.45	203.70

Table 3: 95% confidence for mean for physical properties

Parameter	Farm	95% confidence for mean for physical properties		Minimum	Maximum
		Lower bound	Upper bound		
Clay (%)	50 yrs	27.18	30.93	26.35	29.73
	150 yrs	23.14	25.32	23.84	25.80
Silt (%)	50 yrs	23.11	27.31	23.53	27.45
	150 yrs	26.97	31.85	27.45	31.38
Sand (%)	50 yrs	44.31	47.18	44.23	46.74
	150 yrs	2.09	48.40	44.78	48.71
Moisture content (%)	50 yrs	2.09	5.35	2.70	5.90
	150 yrs	2.97	4.54	3.20	4.80
Particle Density (g/cm^3)	50 yrs	2.40	2.73	2.38	2.75
	150 yrs	2.00	2.39	1.99	2.43

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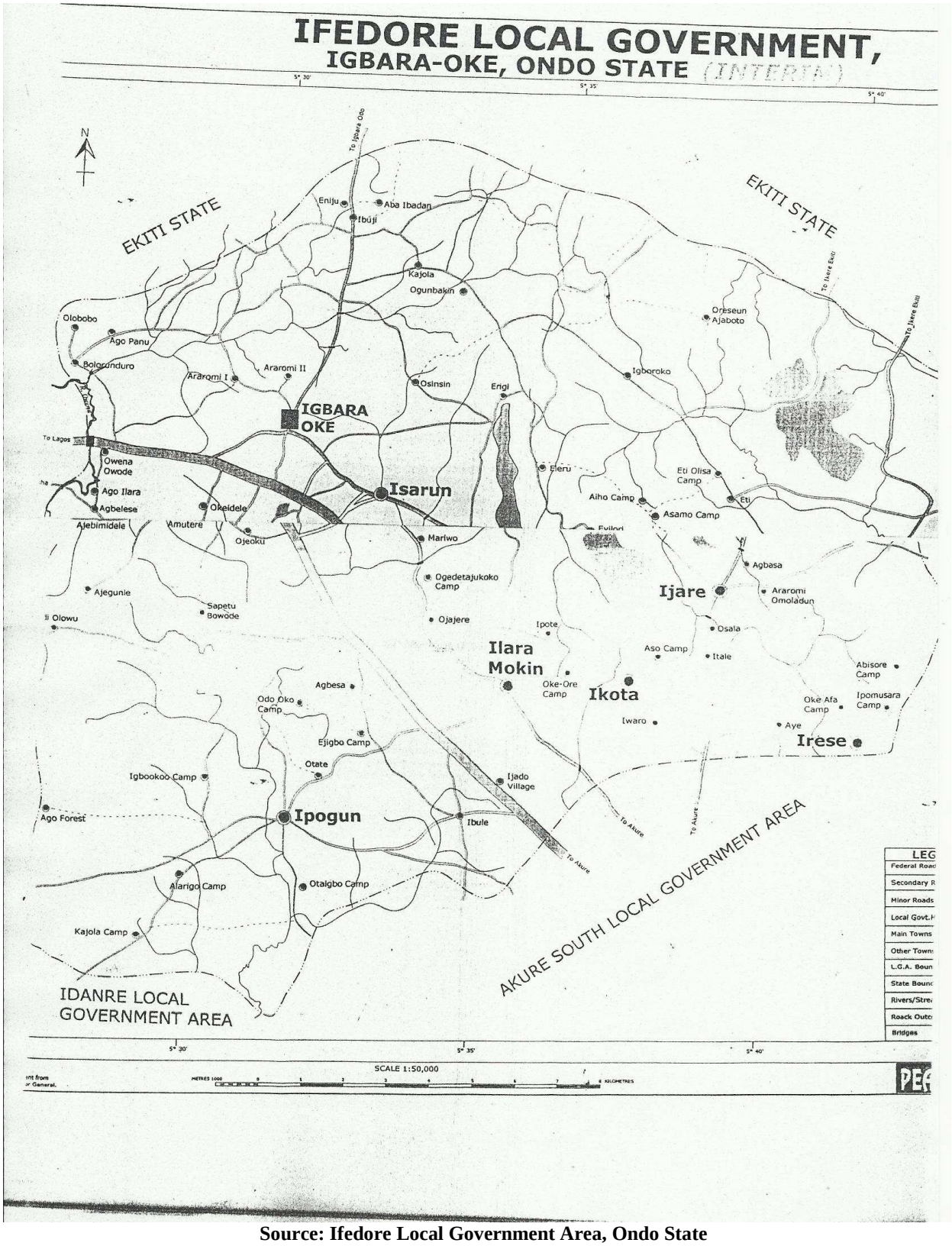

Source: Ifedore Local Government Area, Ondo State